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CARRIER OF SATELLITE AND SPACESHIP. PART I.(U)

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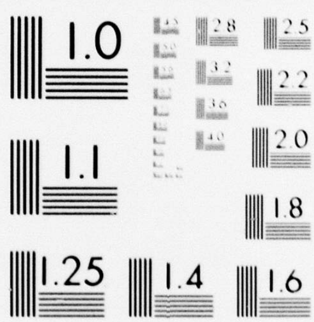

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PART I

by

Ch'i Teng

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PART I

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CARRIER OF SATELLITE AND SPACESHIP -- PART I

Ch'i Teng

With the aid of space carriers, satellites and spaceships can depart from earth and travel in the universe. This article is an introductory description of the carrier vehicles' characteristics, applications, main components, launching orbit and furture prospectives. Because of the length of the article, it will be divided into two parts.

In the production struggle and daily life of the people, commonly encountered transportation means are various types of vehicles, ships and airplanes. In the second half of this century, based on the guided missile and the develop~~emnt~~ment of space technology, people have developed and produced carrier vehicles for satellites and spaceships. Thus, the activity domain of mankind has extended from the earth's surface to outer space. Since a carrier vehicle is an important component of the space flight system, what is it composed of? What are the applications and how does it differ from a guided missile? What is the future prospective?

Uses of Space Carrier

As we all know, man-made satellites revolve around the earth and do not just fall back to ground. This is because the gravitation attraction due to the earth is balanced by the inertial centrifugal force due to the satellite's motion revolving the earth. In order to satisfy this condition,

a speed of 7.9 km/sec is needed. This is the first cosmic speed. If the speed exceeds this and reaches the second cosmic speed (11.2 km/sec), the satellite will escape from the earth and revolve around the sun, becoming a satellite of the solar system. To escape from the gravitational field of the sun, it needs to have the third cosmic speed (16.6 km/sec). How to make the satellite or spaceship acquire the necessary high speed is a vitally important problem.

Up to now, the only way to get to outer space is by the aid of rockets. Unlike an ordinary airplane engine, a rocket carries its own fuel and oxidizer and functions even under a vacuum condition. However, based on the current rocket propellant and technology level, single stage rockets are unable to reach the necessary speed for launching a satellite. Multi-stage rockets are required to achieve the goal. It is expected that single stage rockets capable of delivering a satellite to its orbit and being repeatedly usable may appear in the nineteen eighties.

Space carrier vehicle is generally referring to a multi-stage rocket launched from the earth's surface to provide the necessary speed of a satellite in the earth orbit, or to provide a spaceship with escape velocity.

Space Carrier and Ballistic Guided Missile

The ballistic guided missile played an important role in the development of space flight systems which evolved from the former. The guided missile of the late nineteen thirties had suggested the form of a modern missile. Facist Germany was the first one to use guided missiles during World War II, although unable to alter her fate of defeat. In the mid-fifties, the United States and the Soviet Union spent enormous amounts of money, material and manpower on the research and development of the

guided missile nuclear weapon in their struggle for influence spheres and world dominance. Intercontinental guided missiles came into existence in the late fifties. To satisfy military and engineering demands of weapons, the development of guided missiles provided a broad based technological foundation for the development of space flight systems, and in this very period, the first man-made earth satellite was launched into orbit. The nineteen sixties was the period of rapid progress in space technology and resulted in large scale space carriers. The two super powers, the U.S. and the Soviets, launched a considerable number of military surveillance satellites, communication satellites and weather satellites. Among those, quite a few are synchronous satellites (orbit height 35,860 km).

For low orbit satellites with an orbit height around 300 km, the launching conditions can generally be satisfied by replacing the warhead of an ICBM with the satellite and making some slight modifications. However, the carrying capability of an ICBM alone is insufficient for a high orbit satellite and an additional rocket stage needs to be added to its base. To launch manned lunar landing spaceships or interstellar probes, even larger carriers are needed.

In addition to the payload and warhead, the difference in designing space carriers and guided ballistic weapons shows up in the carrying capability and conditions of operation as well. Being a one-shot weapon used after long periods of storage, the guided missile should have high survival ability. Its mobility should be high and its launching preparation time as short as possible. It should be launched under shelter and its propellant should be loaded rapidly to ready itself before carrying out

its mission. Therefore, its propellant must be storageable and its dimension and weight cannot be too great as to sacrifice its mobility. Under certain situations we would rather lower the carrying ability to ensure that the missile can outlast and meet the demands of war operation. On the other hand, space carriers emphasize the maximum carrying ability. There is no need of extended storage or stringent requirements on launching preparation time, size and weight; hence, low temperature propellant of high energy content and poor storageability can be employed.

The flight orbit of a space carrier is more complex than that of a ballistic missile and its working time is much longer. Reignition of the last stage of a space carrier is sometimes necessary and the weightless condition of the propellant during the carrier's long flight can cause problems in the feeding and the control of the propellant. Although the space carrier and the guided ballistic missile have different missions and design considerations, and they encounter different technical problems, the basic principles of design, manufacture and testing are common to both.

Principal Elements

In general, the space carrier consists of several single stage rockets connected in series (Fig. 1). Sometimes, the lower stages are connected in a parallel fashion and the upper stages in a series, as shown in Fig. 2. The entire carrier can be divided into three main parts: the structure, power device and control system.

The body structure consists of the equipment chamber, the propellant storage tank and the tail section (large carriers may also have a tail fin), with the propellant tank occupying a major portion of the rocket space.

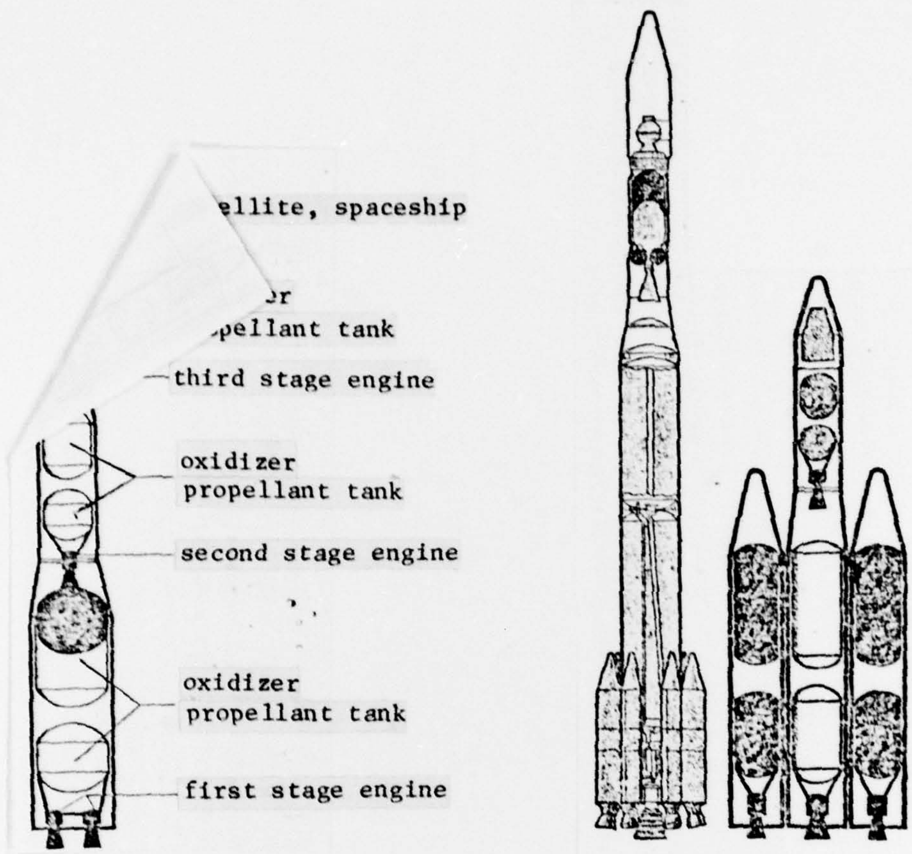

Fig. 1 Series configuration   Fig. 2 Series-parallel configuration

Aside from being the container for the propellant, the propellant tank also serves as the body shell of the carrier and endures the load during flight. Chemical milling is generally used in storage tank manufacturing to reduce the weight. Part of the surface metal of the inner wall is chemically milled away to form a screen or lattice structure; the walls are then welded to form the tank body. (Fig. 3) The oxidizer and the combustant are generally stored in two independent tanks; however, if the carrier length needs to be reduced, they can be stored in one tank with an interior bottom dividing the tank into two compartments. (Fig. 4) An anti-oscillation damping structure is installed in the liquid propellant tank to minimize the propellant's splashing in flight. For a

cryogenic propellant storage tank, a thermal insulation layer is needed to reduce the evaporation of the propellant. The engine is directly mounted on the body frame of the bottom storage tank and the equipment chamber containing the principal instrumentations of the control system is located at the top end of the carrier.

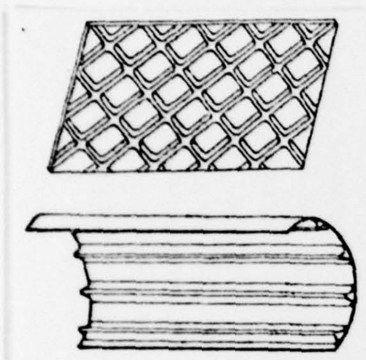

Fig. 3

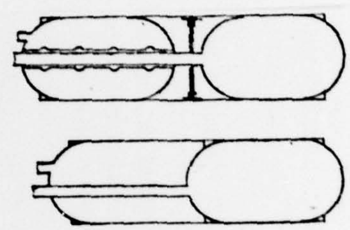

Fig. 4

The power plant consists of the rocket engine and the liquid propellant feeding system. Generally, chemical propellant is either in the solid form or in the liquid form. The specific thrust of a solid propellant rocket engine is lower than that of a liquid propellant engine. (Specific thrust is the thrust produced by burning one kilogram of propellant in one second.) But, as the solid propellant engines are simpler in structure and more reliable, they are generally used as remote engines on satelites or used in the parallel configuration on the first stage as auxiliary propulsion units. (See Fig. 2) Liquid propellant engines have been the main stream of space carrier propulsions systems. Ordinarily the upper two stages use high energy content propellants (e.g. liquid hydrogen/liquid oxygen) and the lower stage uses the regular liquid oxygen/kerosene propellant. The liquid hydrogen/liquid oxygen propellant

is a low temperature propellant of high energy content with a specific thrust as high as 400 sec as compared to the 200-300 sec for regular liquid propellant. Although its low boiling point and poor storageability make liquid H_2/liquid O_2 not suitable for ballistic missiles, it is appropriate for space carriers.

The control system of the carrier consists of the guidance system, the attitude control system, ground launching-test system and the electrical power supply. The common guidance systems of space carriers are the inertial guidance and radio guidance. The inertial guidance system functions on the acceleration information gathered by the instruments carried in the vehicle, principally the gyroscope, the accelerometer and computer. In the radio guidance scheme, the radio or radar equipment on the ground measures the velocity and position of the missile. Such information is then computed and the error-correcting command signal is linked back to the carrier. The carrier corrects its flight course, or cuts off its engine, according to the signal received from the ground. The programmed command signals are carried out by the control force and torque produced by the rotation and shift engines to maintain attitude stability and to change direction.

A space carrier has various kinds of separation systems for the separation of the rocket stages, the separation of the satellite or spaceship from the last stage of rocket, and the separation of the streamline cone of the satellite. An inter-stage separation system should ensure that various stages are securely connected. The system should release the lower stage after it is finished and then reliably start the engine and control system of the stage above it.

Characteristics of Stages

A multistage rocket is one entire entity but each stage has its own features. The first stage provides a steep ascent in the atmosphere. The ratio of its takeoff thrust and weight at takeoff is between 1.2 and 1.5. If this ratio exceeds 1.7, the aerodynamic heating during flight may be too great. When stage separation takes place at about 40 km in the atmosphere, the carrier may experience stability and control problems due to high altitude wind and aerodynamic resistance.

The ratio of thrust and "weight at takeoff" for the upper stages during high altitude flight is usually close to unity. The engine efficiency can be improved further by using high vacuum nozzles.

The last stage of the carrier should have the ability to adjust the velocity of the satellite or spaceship to the precisely predetermined value at the final cutoff of the engine. Most engines have a certain after-effect impulse error which needs to be corrected by using a small nozzle for accurate adjustment of velocity.

The satellite, or spaceship, is installed on the last stage of the carrier rocket, usually under a streamline cone to reduce the damages to the satellite caused by the aerodynamic resistance and the associated pressure and heating when the carrier goes through the atmosphere. Upon reaching a near vacuum condition, the streamline cone is separated and released.

(to be continued)

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